

[0077] The driver 630 may control the diode 640 according to the voltage or the current received from the V/I controller 620.

[0078] The diode 640 may include a plurality of light-emitting elements and emit light. The diode 640 may emit IR signals having a plurality of phases.

[0079] The lens 680 may refract received light. Light passing through the lens 680 may reach the image sensor 670.

[0080] The image sensor 670 may convert light passing through the lens 680 into an electrical signal. The image sensor 670 may output the electrical signal to the memory 660. The image sensor 670 may output IR signals having a plurality of phases to the memory 660.

[0081] The memory 660 may store data received from the image sensor 670. The memory 660 may receive and store signals corresponding to the plurality of phases from the image sensor 670.

[0082] The processor 610 may read data stored in the memory 660. The processor 610 may read only some of data stored in the memory 660. For example, in a case where pieces of image data of four phases are stored in the memory 660, the processor 610 may read only one piece of data from the memory 660.

[0083] FIG. 7 is a flowchart of a method of adjusting the light intensity of the light source 530, according to an exemplary embodiment. Referring to FIG. 7, the processor 610 may gradually reduce or increase the light intensity of the light source 530 up to a maximum light intensity at which the IR image is unsaturated. In other words, the processor 610 may output a signal designating the magnitude of the voltage or the current to the V/I controller 620 according to the saturation or unsaturation of the IR image.

[0084] In operation 701, the processor 610 may set the light intensity of the light source 530 to X1 and set a gain of the receiver 510 to G1. The processor 610 may determine the magnitude of the voltage or the current output by the V/I controller 620 and set the light intensity of the light source 530. For example, the light source 530 may have four levels of light intensity X1 to X4. The light source 530 may have four or more levels or less than four levels of light intensity. X1 represents the highest level of the light intensity of the light source 530, and X4 represents the lowest level of the light intensity of the light source 530. In other words, the light intensity of the light source 530 gradually decreases in the order from X1 to X4.

[0085] The processor 610 may set the gain of the receiver 510 to G1. For example, the processor 610 may set gains of amplifiers included in the image sensor 670 to G1. G1 represents the highest level of the gain of the receiver 510, and G4 represents the lowest level of the gain of the receiver 510. The gain of the receiver 510 gradually decreases in the order from G1 to G4.

[0086] In operation 702, the processor 610 may determine whether the number of saturated pixels among pixels of a first image is greater than A. A may be any natural number and may be a value less than the number of pixels included in one image. The saturated pixel may be a pixel having a pixel value that is greater than a saturation threshold value.

[0087] The processor 610 may set and change a reference threshold value. # Sat may represent the number of saturated pixels. When the number of saturated pixels is greater than A, the light intensity of the light source 530 is high. Therefore, the processor 610 may proceed to operation 703

so as to adjust the light intensity of the light source 530. When the number of saturated pixels is less than or equal to A, the processor 610 may determine that the image is unsaturated and return to operation 701.

[0088] The first image may be an image acquired when the light intensity of the light source 530 is X1 and the gain of the receiver 510 is G1. For example, the light source 530 may output an IR signal which has an intensity that is X1, and the receiver 510 may receive a reflected signal and amplify the reflected signal by G1. The processor 610 may generate a first image based on the reflected signal received from the receiver 510. In operation 703, the processor 610 may set the light intensity of the light source 530 to X2 and set the gain of the receiver 510 to G2. Since it is determined that the image is saturated, the processor 610 may reduce both or either of the light intensity of the light source 530 and the gain of the receiver 510.

[0089] In operation 704, the processor 610 may determine whether the number of saturated pixels among pixels of the second image is greater than A. The second image may be an image acquired when the light intensity of the light source 530 is X2 and the gain of the receiver 510 is G2. In other words, the processor 610 may generate the second image based on a reflected signal acquired in a state in which the light intensity of the light source 530 or the gain of the receiver 510 is reduced, and determine whether the number of saturated pixels in the second image is greater than A.

[0090] When the number of saturated pixels is greater than A, the light intensity of the light source 530 is high. Therefore, the processor 610 may proceed to operation 705 so as to adjust the light intensity of the light source 530. When the number of saturated pixels is less than or equal to A, the processor 610 may determine that the image is unsaturated and proceed to operation 708.

[0091] In operation 705, the processor 610 may set the light intensity of the light source 530 to X3 and set the gain of the receiver 510 to G3.

[0092] In operation 706, the processor 610 may determine whether the number of saturated pixels among pixels of the third image is greater than A. The second image may be an image acquired when the light intensity of the light source 530 is X2 and the gain of the receiver 510 is G3.

[0093] When the number of saturated pixels is greater than A, the light intensity of the light source 530 is high. Therefore, the processor 610 may proceed to operation 707 so as to adjust the light intensity of the light source 530. When the number of saturated pixels is less than or equal to A, the processor 610 may determine that the image is unsaturated and proceed to operation 709.

[0094] In operation 707, the processor 610 may set the light intensity of the light source 530 to X4 and set the gain of the receiver 510 to G4.

[0095] In operation 708, the processor 610 may determine whether the number of unsaturated pixels among the pixels of the second image is less than B. B may be any natural number and may be 0. For example, when B is set to 0, the processor 610 may determine in operation 708 whether there are no unsaturated pixels. B may be a threshold value for determining the second image as the unsaturated image. # eSat may represent the number of unsaturated pixels. The unsaturated pixel may be a pixel having a pixel value that is less than an unsaturation threshold value. The processor 610 may determine the product of the saturation threshold value and e as the unsaturation threshold value. e may be greater